SCIENCE FOR GLASS PRODUCTION

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CORROSION RESISTANCE OF FLOAT GLASS

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The corrosion resistance of float glass has been investigated in the course of climatic tests. It is shown that the main surface defects of tempered glass are leaching and "burnt-on paper and sulfurous film." The properties of various interleaving materials used in the domestic industry are studied. The corrosion resistance of tempered glass depends on the surface of the initial glass and the properties of the interleaving material used for packing the initial as well as the tempered glass.

An important indicator of glass quality is the resistance of the glass to chemicals, i.e., the glass's ability to withstand the destructive effect of various reagents.

In use, sheet glass is most often exposed to water and atmospheric moisture. In addition, if the glass installed in buildings and various structures as well as in means of transport reliably withstands exposure to atmospheric precipitation for many years, stacked glass can be subjected to corrosion during shipment and storage even within a short period of time. Weak irisation appears on the surface of the glass sheets, gradually spreading and forming white spots and deeper damage. In extreme cases, flaking of the glass surface can occur [1].

These phenomena, called leaching of the glass, substantially degrade the transparency of the glass and can make the glass completely unusable (Fig. 1). Therefore, determining the factors influencing the corrosion resistance of float glass is of practical value and points to a need for research work.

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Various methods consisting of simulating the climatic effect on a glass surface under laboratory conditions are used to evaluate the corrosion resistance of glass. The existing methods are distinguished by their methodological formulation and the equipment used, but they are all based on the process of accelerated corrosion of glass under conditions with elevated humidity.

For example, according to a method used to study the corrosion resistance of glass, a tropic chamber is used. The glass samples all have the same size and are placed in stacks inside a chamber with the temperature kept constant at $54 \pm 1°C$ with 100% humidity. Under these conditions the surface of the glass samples is subjected to rapid corrosion: interference coloration already appears after several days, then dull spots (initial stage of leaching) appear, and finally complete corrosion of the glass occurs for sufficiently long testing times. This method is used for comparative studies and requires that certain test conditions be maintained precisely [1].

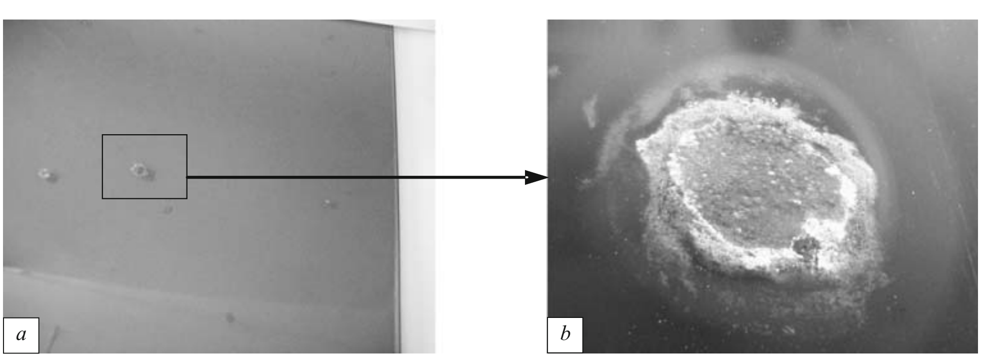

Fig. 1. "Leaching" defect at the top surface of float glass: *a*) overall view of a sheet of float glass with leaching spots; *b*) leaching spot (× 45).

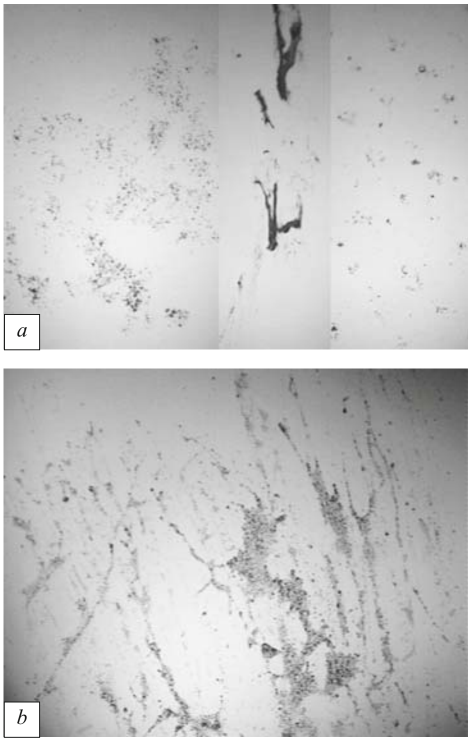

Fig. 2. Tracks on the surface of the initial (*a*) and tempered (*b*) glass (× 17.5).

In France, a facility consisting of a "Precision Thelco Model 6" drying furnace with a chamber with regulatable cyclic humidity is used for accelerated tests of the corrosion resistance of glass. During the period of heating up to 70°C, which lasts for 90 min, water is evaporated into the chamber and an atmosphere with elevated humidity is created around the glass samples. During the period of cooling to 49°C, which also lasts for 90 min, water condenses out of the atmosphere onto the glass samples. Such repeating heating and cooling cycles accelerate the effect of the atmosphere on the surface of the glass samples being tested and cause corrosion of the glass. As a result of repeated tests it was determined that one-day tests in this facility correspond to exposure to the atmosphere for six to eight months of a stack of glass under actual storage conditions (French patent No. 1343914).

In the research work performed at the Saratov Glass Institute JSC, laboratory tests of the corrosion resistance of float glass were performed using a hygrostat (G-4). The glass samples were arranged in stacks and placed in the hygrostat and subjected to periodic heating and cooling from 70 to 49°C) with 100% humidity. The resistance of the glass to the action of the humid atmosphere was evaluated by visual examination in definite intervals of time with a detailed description of the degree of damage on the top surface (in contact with the protective atmosphere during the time the glass was in production) and the bottom surface (in contact with the tin melt) of each sample.

It should be noted that this method, which is highly reliable and informative, makes it possible to evaluate the quality of the surface of float glass as well as that of the interleaving material used for packing the glass.

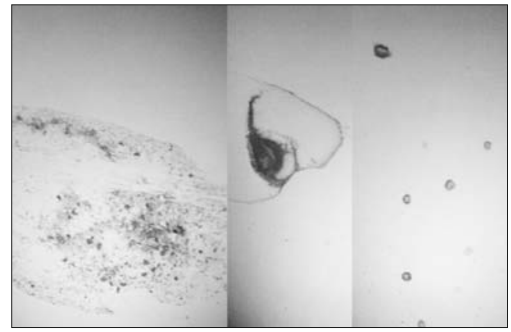

Fig. 3. Leaching tracks on the surface of quenched glass after the climatic tests (× 17.5).

Float glass, especially tempered float glass, is now most often used as a construction material which can withstand different operational loads. Experience shows that under identical conditions tempered glass is more vulnerable to leaching than untempered glass. According to the published data, water and atmospheric humidity break down tempered glasses approximately 1.5 times more strongly than well-annealed glasses [2].

To determine the reasons for the decrease of the corrosion resistance of tempered glass, we investigated samples of heat-absorbing (Saratov Glass Institute JSC) and colorless (Bor Glass Works JSC) float-glass. To perform a comparative analysis, batches of samples of tempered and initial glass were tested. Different stacking methods were used when placing the samples into the chamber — with and without different types of interleaving material.

The climatic tests performed on the quenched glass showed that the centers of leaching on the glass, as a rule, were surface defects such as different types of baked spots, scratches, and wear spots. Detailed investigations showed that such defects appear because of disruptions of the technology used to prepare the initial glass for tempering. Figure 2*a* shows tracks on the surface of the initial glass: these could be imprints of fingers, dirty stains, or very small glass particles. It should be noted that such tracks can be easily washed off the surface of the initial glass, but nothing can remove them after tempering (Fig. 2*b*). Subsequently, these defects can become centers for the onset of leaching of the glass (Fig. 3).

During the climatic tests, aside from leaching, we also found on the surface of the initial and tempered glass a defect of the type "burnt on paper and sulfide film," comprising a blue-gray – brown veil which cannot be washed off. It was determined that the "burnt on sulfide film (sodium sulfate)" defect in the form of spots or stains appears only the glass surface which is in direct contact with the sulfur-gas-treated bottom surface of the neighboring sample. Consequently, the entire surface of the initial glass must be covered with paper at any stage of the preparation of the glass for tempering.

Fig. 4. Sample of packaging paper (*a*) and sample of the heat-absorbing glass with a "burnt on paper" defect (*b*).

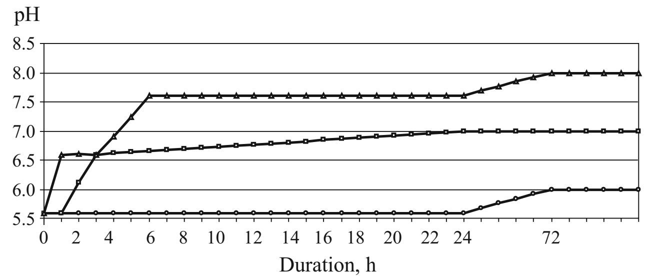

Fig. 5. Variation of the pH of solutions with different types of paper.

The "burnt on paper" defect forms on the top surface of the glass as a result of contact with the interleaving material. The time at which this defect appears depends on the conditions and duration of storage of the initial glass in packaged form. It can be supposed that "burnt on paper" appears because of the presence of a sulfate base in the interleave material, since according to color this defect corresponds to a "burnt on sulfide film." But in this case the pattern of the paper is precisely copied. Figure 4*a* shows a sample of the packaging paper and Fig. 4*b* shows a sample of the glass on whose surface a burnt-on imprint is seen in the form of an imprint of the paper; the imprint appeared four days after the tests in the hygrostat.

It should be note that in the course of the climatic test of the glass samples placed in the hygrostat without the interleaving paper, a "burnt on paper" defect was also observed on their surfaces. Evidently, this can be explained as a manifestation of an invisible imprint of the packaging paper, which was interleaved between the glass sheets immediately after the sheets were produced in the float line.

In addition, we studied the properties of the different forms of interlayer material used for packaging the glass in the domestic industry (several types of paper and a cork material in the form of slabs). According to the published data, the packaging paper must have a low hygroscopicity, good mechanical strength, and an acidic medium (pH = 6), i.e., it should not increase the propensity of the glass for leaching [3].

Our investigations showed that the pH of the interleaving materials is not the same and ranges from 5 to 8. Figure 5 shows the temporal variation of the pH of individual types of paper in a moist medium.

The climatic tests performed on the samples of heat-absorbing glass (cut from the same sheet) interleaved with different types of paper established that in time (4 – 60 days or longer) defects which cannot be removed in any way (burnt-on and leaching) appear on the surface of the samples. In addition, the higher the pH of the paper used, the sooner the defects appear on the top and bottom surfaces.

The tests of the six types of packing paper showed that three types of paper (pH = 6) lasted the longest period of time (more than 50 days in a hygrostat) before irremovable defects appeared. However, two of these papers lost their mechanical strength (they came apart) during the tests and only one type of paper withstood more than 60 days of testing, retaining strength, integrity, and smoothness.

Investigations of the cork material showed that after climatic test this material separated from the surface of the glass, leaving an irremovable track on the glass surface. The leaching around the cork, secured on the bottom surface of the samples, already started 7 days after the test in the hygrostat, even though the pH of the cork was 5 – 6. It is evident that cork material should not be used when glass is stored under humid conditions. Therefore, the choice of the interleaving material is of great consequence for protecting float glass (especially tempered glass) from leaching and requires a careful approach.

In summary, the corrosion resistance of tempered glass is largely determined by the cleanliness of the surface of the initial glass and the properties of the interleaving material used for packaging the initial and tempered glass.

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